

## Applications of Low Density Flow Techniques and Catalytic Recombination at the Johnson Space Center

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The talk presents a brief background on definitions of catalysis and effects associated with chemically nonequilibrium and low-density flows of aerospace interest. Applications of catalytic recombination on surfaces in dissociated flow are given, including aeroheating on reentry spacecraft thermal protection surfaces and reflection of plume flow on pressure distributions associated with the space station. Examples include aeroheating predictions for the X-38 test vehicle, the inlet of a proposed gas-sampling probe used in high enthalpy test facilities, and a parabolic body at angle of attack. The effect of accommodation coefficients on thruster induced pressure distributions is also included. Examples of tools used include simple aeroheating formulas based on boundary layer solutions, an engineering approximation that uses axisymmetric viscous shock layer flow to simulate full three dimensional flow, full computational fluid dynamics, and direct simulation Monte-Carlo calculations. Methods of determining catalytic recombination rates in arc jet flow are discussed. An area of catalysis not fully understood is the formation of single-wall carbon nanotubes (SWNT) with gas phase or nano-size metal particles. The Johnson Space Center is making SWNTs using both a laser ablation technique and an electric arc vaporization technique.